Chapter 1

Space Science: Origins, Evolution, and Organization

by

John E. Naugle and John M. Logsdon

Modern space science really began in 1946 when scientists first started to use balloons and sounding rockets to carry instruments to the outer fringes of the Earth's upper atmosphere. With the latest technological advances, balloons could float at an altitude of 100,000 feet for several hours, enabling scientists to study cosmic rays and other atmospheric and stellar phenomena. Soon after, sounding rockets soaring to 400,000 feet gave scientists a fleeting glimpse of the ultra-violet and x-ray radiation from the Sun and stars. Almost ten years of upper atmosphere science using these new tools created a community of scientists eager to extend their observations. These efforts were followed by the International Geophysical Year in 1957-1958, when scientists planned to orbit satellites for their research. They recognized that satellites could provide months of observing time hundreds of miles above the Earth's atmosphere, something neither balloons nor sounding rockets could do.[1]

When the Soviet Union launched *Sputnik I* on October 4, 1957, public reaction fostered greater efforts in space science as an attempt to atone for the Cold War humiliation. As a result, the United States began to pour heretofore-undreamed-of resources into space science. Hundreds of scientists shifted their research arena from Earthbound research laboratories to Earth orbit and the remote reaches of the solar system. Some were driven by the opportunities to discover new phenomena; others were enticed by the resources available in a growing, exciting, and dynamic field.

To manage these efforts, in July 1958 the United States created a new agency, the National Aeronautics and Space Administration (NASA). Americans expected NASA to organize a coherent national space science program that would regain U.S. leadership in space science and technology. It took NASA and space scientists nearly six years to achieve a coordinated , mutually agreeable program, but from 1964 through to the present NASA has conducted a sophisticated, productive space science program, though not without continuing tension between the space agency and space scientists. During that period several thousand astronomers, physicists, chemists, and life scientists have conducted experiments on NASA missions, and the results of NASA's programs have revolutionized human understanding of Earth's place in the cosmos.

The Origins of Space Science (1946-1958)

In the years immediately following World War II, the U.S. scientific community turned its attention from support of the war effort to the scientific questions that had been the focus of attention before the war. As they did so, new techniques for obtaining data became available; that development marked the beginning of the U.S. space science effort.

Balloons, Cosmic Rays, and Mesons

After World War II, the Office of Naval Research started the Skyhook balloon program. Although the Navy justified support of the program because of its eventual value to military systems, civilian scientists established the objectives of the program and conducted the research. Large plastic balloons carried cosmic ray instruments to altitudes above 100,000 feet. Because the cost of the balloon program was relatively low and because graduate students could assemble a payload in a few months in a university laboratory, the Skyhook program enabled many academic scientists and graduate students to study cosmic rays.[2]

V. F. Hess, an Austrian physicist, had discovered cosmic rays in 1911 while searching for the source of a highly penetrating radiation. He personally carried a Wulf electrometer to a height of 5,000 meters in an open gondola, where he found the ionization to be sixteen times that at the surface. Hess correctly interpreted his observations as demonstrating that the highly penetrating radiation came from outside the atmosphere rather than from the surface of the Earth. Physicists could not immediately determine the nature of the radiation. Since it came from outside the Earth—from the cosmos—they named the phenomenon "cosmic rays." By 1940, when World War II stopped cosmic ray research, physicists knew that most cosmic rays were positively charged particles of great energy that, upon entering the atmosphere, generated cascading showers of electrons, positrons, gamma rays and some kind of unknown, highly penetrating charged particles.

In 1947, scientists at the University of Bristol exposed thick, very sensitive photographic "nuclear emulsions," to cosmic rays on a mountaintop in the Alps. In the emulsions they found the tracks of two new particles, heavier than a proton and lighter than an electron. They named these new particles the *pi* and *mu* mesons.[3] The *pi* meson proved to be the glue that held a nucleus together and the *mu* meson, the mysterious highly penetrating particle in cosmic rays. In 1948, using a Skyhook balloon to expose nuclear emulsions to cosmic rays at high altitudes, scientists at the University of Minnesota and the University of Rochester discovered that, in addition to protons and electrons, cosmic rays also included high-energy atomic nuclei stripped of their electrons.[4] These two scientific discoveries sparked intense interest in cosmic rays. For about a decade, until proton accelerators replaced cosmic rays as a source of mesons, cosmic rays and their nuclear interactions occupied center stage in theoretical physics. Many future space scientists took up the study of cosmic rays in this period.

In the mid-fifties, just as proton beams from accelerators were replacing cosmic rays as sources of mesons, scientists discovered that during a solar flare, the Sun emitted large numbers of cosmic rays and modulated the flux of cosmic rays coming from outside the solar system. These two discoveries, coupled with anticipation of the onset of a period of high solar activity in 1957, stimulated a renewed interest in cosmic rays. Unfortunately, the time of onset of a solar flare is unpredictable and it reaches its peak intensity in a few minutes. Sounding rockets and balloons were not good enough platforms to study solar flares, because it was difficult to launch them on such short notice. On the other hand, a satellite would be an ideal platform. From such a platform outside the Earth's atmosphere, a scientist could continuously monitor cosmic rays. After 1958, large numbers of cosmic ray physicists entered the fray, determined to be the first to get a cosmic ray detector on a satellite. They were young, eager and full of ideas for experiments that required satellites and space probes. Meanwhile, other groups of scientists had been using rockets to observe the Sun and stars. They were equally interested in getting their telescopes onto satellites.

V-2 Upper Atmosphere Panel

At the end of World War II in May 1945, the U.S. Army acquired a number German V-2 rockets, together with many of the engineers who had developed them (including Wernher von Braun), and brought the rockets back to the United States for examination and testing. In late 1945, the Army offered scientists the opportunity to put experiments aboard these rockets as they were launched for engineering tests. This offer led to the formation of an ad hoc "V-2 Upper

Atmosphere Panel" in February 1946, to "develop a scientific program, assign priorities for experiments to fly on the V-2s, and to advise the Army Ordnance Department on matters essential to the success of the program."[5]

Working through the panel, astronomers and geophysicists used these sounding rockets to study the properties of the upper atmosphere, solar and stellar ultraviolet radiation, and the aurora. Scientists used all the V-2s, then used new sounding rockets developed to replace them, and continued to control the nation's sounding rocket program until NASA Headquarters took over this function in 1958.[6] The minutes of the meetings of the V-2 Upper Atmosphere Panel provide a vivid history of the many failures and occasional triumphs of these first space scientists. [I-1, I-2, I-3] After the formation of NASA, several members of the V-2 Panel joined the space agency and applied the experience they had gained to the organization and management of NASA's space science program. Together with those scientists who had been conducting balloon experiments, these "rocket scientists" formed the nucleus of the initial U.S. space science community.[7]

International Geophysical Year

The members of the V-2 Panel and the cosmic ray physicists were a small minority of the many other astronomers and geophysicists interested in the intense solar activity predicted for 1957. In 1952, scientists Lloyd Berkner, Sidney Chapman, and Marcel Nicolet persuaded the International Council of Scientific Unions (ICSU) to organize an International Geophysical Year (IGY), a cooperative scientific endeavor to study solar-terrestrial relations during the period of maximum solar activity. Some 67 nations, including the Soviet Union, agreed to conduct cooperative experiments to study solar-terrestrial relations during the IGY.

In October 1954, ICSU challenged the United States and the USSR to use their missiles, being developed for war, to launch scientific satellites as part of the IGY program. In July 1955, the United States responded by announcing that it would develop a new rocket, the Vanguard, to launch scientific satellites. A year later, the Soviets announced that they too would launch scientific satellites as a part of the IGY. Thus began a race to see who would be first to launch an Earth satellite.

A National Security Council white paper approved by President Dwight D. Eisenhower, "U. S. Scientific Satellite Program," provided the rationale behind the satellite program. [Volume I, Document I-10] This paper, discussed on May 20, 1955 by the White House National Security Council (NSC), encouraged the Department of Defense to develop and launch a small scientific satellite, "under international auspices, such as the International Geophysical Year, in order to emphasize its peaceful purposes, . . . considerable prestige and psychological benefits will accrue to the nation which first is successful in launching a satellite . . . especially if the USSR were to be the first to establish a satellite." This document summarizes many of the forces that shaped space science over the coming years. The paper justified space science because of its contribution to national security, not because it was an activity worthy of support on its own merits. Eisenhower and his associates were primarily interested in establishing the international legal principle that national sovereignty did not extend to the altitudes at which a satellite would orbit, and thus that there was no obstacle in international law to the overflight of a reconnaissance satellite over Soviet territory. To them, the scientific purposes of the satellite were of secondary importance. [Volume I, Document II-12]

Within two months, the Naval Research Laboratory's proposal to develop a new Vanguard rocket to launch initial U.S. scientific satellites was chosen over the Army's competing Project Orbiter proposal by an “Ad Hoc Advisory Group on Special Capabilities.” [Volume IV, Document I-4] The organization, conduct, and initial failure of the Vanguard Program stimulated the space science effort and helped shape its organization.

Although the Naval Research Laboratory (NRL) managed the Vanguard program, the overall scientific and technical direction came from a Technical Panel for the Earth Satellite Program (TPESP). The National Academy of Sciences and its operating arm the National Research Council organized TPESP, which consisted mostly of scientists. [I-4] Richard Porter, an engineer from General Electric who had been in charge of the U.S. V-2 program, chaired TPESP. The Panel directed the work, set policies, selected experiments, and formulated scientific objectives for the Vanguard project. The National Science Foundation, Army, Navy, and Air Force participated in the work and provided funds to pay for it.[8] However, it was the TPESP, which met about once a month, that controlled the pace and scientific content of Vanguard. Although NRL was responsible for building Vanguard, it could not start work on the payload for a mission until the Panel had established the objectives of the mission and selected the experiments.[9] [I-5]

The Vanguard program proved much more difficult to accomplish, and therefore much more costly, than had been anticipated. The original cost estimate for the program was $15-20 million; by the spring of 1957, the estimate had grown to $110 million, with possible growth to $150-200 million. President Eisenhower and the National Security Council considered canceling the program in May 1956, but decided to let it continue. The Eisenhower administration in mid-1956 also considered, but rejected, the possibility of authorizing the Army to attempt a satellite launch in advance of the first scheduled launch in the Vanguard program. [Volume IV, Document I-7, I-8] By 1957, neither the Defense Department nor the National Science

Foundation was eager to provide the additional funds to complete Vanguard; it took White House intervention to force them to do so. [I-8]

Sputnik

In the fall of 1957, as TPESP's cumbersome machinery ground on and Vanguard continued to fall behind schedule, the governing body of the IGY met in Washington, D. C. On Friday, October 4, 1957, the Soviet Union hosted a party for the group at its Embassy. Midway through the party, Lloyd V. Berkner, a prime mover behind the IGY and president of the International Council of Scientific Unions, announced that the Soviets had just launched a satellite.[10] The dramatic launch of the first satellite, *Sputnik I*, surprised the world. The Soviets had opened the age of space exploration. The successful launch of Sputnik set off an accelerated U.S. effort to launch a satellite, despite attempts by President Eisenhower and his associates to minimize the significance of the Soviet accomplishment. [I-9 and Volume IV, Document I-9 and I-10] At its November 6 meeting, TPESP agreed that if there were a decision by the Department of Defense to provide one or more of Wernher von Braun's Jupiter C rockets as a backup to the Vanguard, one of the experiment packages it had approved would be shifted from a Vanguard launch attempt to the initial Jupiter C attempt. [I-10] On November 8, 1957, Secretary of Defense Neil H. McElroy indeed did direct the Army to use its Jupiter C launch vehicle to launch two satellites.

In early November, the Soviets launched *Sputnik II* with a dog named *Laika* aboard. In December, the United States attempted to launch the first Vanguard. The rocket burst into flames, crumpled, and dumped its satellite back onto the launch pad. So far, the score was 2-0 in favor of the Soviets.

On January 31, 1958, Wernher von Braun, leader of the German engineers who developed the original V-2s, the Redstone, and the Jupiter C, used the Jupiter C to place *Explorer I*, the first American satellite, in orbit. The satellite had been developed by the Army's Jet Propulsion Laboratory, and carried an experiment designed by one of the individuals who had been involved in shaping initial U.S. involvement in space science research, James van Allen of the University of Iowa. Even after the 1955 selection of Vanguard as the sole U.S. scientific satellite project, van Allen had remained in touch with the von Braun team in Alabama, and thus was quickly able to switch his payload from the Vanguard launcher to the Jupiter launcher after that opportunity became available. [I-6, I-7]

The Van Allen Belts

Riding on *Explorer I* were Geiger counters built by Van Allen. On May 1, 1958, at a joint session of the American Physical Society and the National Academy of Sciences, Van Allen announced the most significant discovery from *Explorer I* and the subsequent *Explorer III* mission, then in orbit: that there were high energy radiation belts surrounding the Earth.[11] [I-12] These "Van Allen Belts" consisted of doughnut shaped regions of space centered on the geomagnetic equator and filled with high energy (40 MEV) protons orbiting around magnetic lines of force and oscillating back and forth between the northern and southern hemispheres. The belts proved to be more than just an exciting scientific discovery; the radiation level in the belts was so intense that, if a human or a satellite were orbiting within them, he or she would receive a lethal dose of radiation in a few hours, solar cells would rapidly deteriorate, and electronic equipment would malfunction. Because of the belts, almost all Earth satellites have been placed in orbits either below or beyond them. Whereas the Sputniks had not produced any exciting or significant scientific results, Van Allen's discovery electrified the scientific community. Van

Allen and his hard-working graduate students had demonstrated that a team of academic scientists could design and build instruments that worked in space. Later, when engineers argued that academic scientists were not qualified to build instruments for spacecraft, someone was sure to remind them of *Explorer I*. Van Allen's unexpected discovery and the worldwide acclaim he received attracted many young people to space science.

Creating a National Space Science Organization

In the near hysteria that prevailed after the success of the first two Sputniks and the failure of the first Vanguard, the United States began an intense effort to create a space program that would restore American pride and prestige. The Speaker of the House, Joe Martin, and the Senate Majority Leader, Lyndon Johnson, each chaired hearings to learn why the United States had fallen behind and how best to organize the U.S. response. Many organizations fought to gain control of the nation's space effort.[12] After *Sputnik I*, the Rocket and Satellite Research Panel (the successor to the V-2 Upper Atmosphere Panel, which had become the Upper Atmosphere Rocket Research Panel in 1948 and had changed its name again in 1957) doubled its membership. Its members prepared a plan for a civilian agency to take over the exploration of space and then testified before Congress in favor of their plan. [I-11] That plan best represented the views of the nascent U.S. space science community as the nation organized its space response to Sputnik.

The Space Act

In March 1958, President Eisenhower, under attack by the media and a Democratically controlled Congress, selected the National Advisory Committee for Aeronautics (NACA) to become the core of the new space agency. He sent a bill to Congress, which when revised became the National Aeronautics and Space Act of 1958. The president signed this act into law on July 29, 1958. [Volume I, Document II-17]

The Space Act was, and still is, significant to space science, not only because of what it says about space science, but also by what it left unsaid. The Act stated that the general welfare and security of the United States required space activities and listed eight objectives for those activities. The first objective: “the expansion of human knowledge of phenomena in the atmosphere and space” made space science a high priority for NASA. The fifth objective set a goal for space science: “The preservation of the role of the United States as a leader in aeronautical and space science and technology . . . .” This statement set a relative rather than an absolute goal for space science. In 1958, there were only two countries with space programs; therefore it tied federal support for space science directly to the relative status of the United States and the Soviet space science programs.

The Act directed the Administrator of NASA to arrange for scientists to help plan the scientific measurements and observations to be made, to conduct itself or arrange for another party to make those measurements and observations, and to provide for the widest possible dissemination of their results. The Act did not state how the Administrator was to involve scientists in planning, but directed that the Administrator be responsible for planning and conducting space science. If a spacecraft failed, or the Soviets scored a first, Congress wanted one individual held accountable, not a committee or two or three cooperating agencies.

The Space Science Board

As the administration and Congress moved to create NASA and the staff of the NACA worked to make that organization the core of the new space agency, scientists organized themselves to participate in the planning and execution of the program. On June 4, 1958, President of the National Academy of Sciences Detlev Bronk created a Space Science Board. The members of the Board, mostly senior academic scientists, were asked to draft a space science program, identify institutions and scientists to conduct the program, and provide their recommendations to the Administrator of the new NASA, once it began operations. Bronk appointed Lloyd V. Berkner, a dynamic, hard-driving scientist, to be Chairman of the Space Science Board. [I-13]

Between June and October, Berkner organized the Board, and sent a telegram to scientists and scientific institutions that invited them to propose space science experiments. [I-14] He created committees to evaluate the two hundred proposals the Board received. In December 1958, the Board recommended an initial scientific program of over thirty missions to the NASA Administrator, and issued a primer on space science to allow other scientists to propose additional experiments. [I-15, I-16] These missions ranged in size from sounding rockets to solar and astronomical observatories. The members of the Board thought they were recommending a program for the next two or three years. It took NASA the better part of the next decade to complete that program.

NASA Establishes Its Space Science Program

On October 1, 1958, when T. Keith Glennan, the first Administrator of NASA, opened the doors of the new agency, he had no space scientists on his staff and no space science program at any of the NASA centers. Under the Space Act, Glennan had the option of either having NASA conduct the space science program or arranging for other agencies, such as the National Science Foundation (NSF), to conduct it. He decided that NASA should be responsible for space science and created the Office of Space Flight Programs at NASA Headquarters. He appointed Abe Silverstein, a propulsion engineer from the NACA Lewis Research Laboratory, as its director. In turn, Silverstein appointed Homer E. Newell[13] to be his Assistant Director for Space Sciences at NASA Headquarters. To conduct the program, The Eisenhower administration transferred from the Army to NASA control over the Jet Propulsion Laboratory (JPL) in Pasadena, California, which was operated by the California Institute of Technology, and created a new “field center,” the Goddard Space Flight Center (GSFC) in suburban Maryland near Washington.[14] Besides Newell, an additional fifty NRL scientists transferred to NASA. Most went into a Space Science Division at GSFC. Two came to NASA Headquarters to help Newell administer the space science program. In December 1958, Administrator T. Keith Glennan issued a document that specified how he intended to plan and conduct the space science program. This document outlined the objectives for NASA’s space flight experiments, and stated that the research program would be national in scope and would be based on recommendations from, among other groups, the Space Science Board. NASA would ask educational and research institutions, industry, and federal laboratories to participate in the program. NASA, not the Space Science Board, would establish the priorities for experiments and projects.[15]

By the beginning of 1959, Newell had a clear and unambiguous mandate to organize and manage a comprehensive space science program. At NASA Headquarters he had only a three-man staff, hardly adequate to administer a large and complex program that involved NASA centers, universities, and industry. [I-18] In addition, he was engaged in a tug-of-war with the Space Science Board for control of the space science program. He also had a battle going with William Pickering, the director of JPL, as to whether NASA Headquarters or JPL would formulate the lunar and planetary program that JPL had chosen as its desired share of the space science effort.

The Space Science Board expected to function with NASA somewhat as TPESP had functioned with respect to the Navy in the Vanguard program. During 1959, as Newell increased the size of his staff and moved to take charge of the program, the Board continued in its self-appointed role. Finally, on October 29, 1959, NASA used the power of the purse to take control. In a letter that provided funds for the operation of the Board for 1960, NASA directed the Board to focus on long-range strategy for space science and leave the detailed planning and conduct of the program to NASA. [I-17]

The Reorganization of 1959

In addition to the external problems with the Space Science Board, there were internal problems with NASA organization. In December 1959, to clarify the roles and missions of the centers (and for a variety of other reasons), Glennan reorganized NASA. He assigned the responsibility for all automated lunar and planetary missions to JPL. All Earth satellite and sounding rocket missions went to Goddard. [I-19]

Following Glennan's reorganization, Silverstein reorganized the Office of Space Flight Programs; he abolished Newell's Office of Space Sciences (OSS) and created two new program offices—Lunar and Planetary Programs and Satellite and Sounding Rocket Programs—to replace it. He appointed Newell, a scientist, as his deputy. He appointed former National Advisory Committee for Aeronautics (NACA) engineers to head each of the program offices and appointed scientists to be their deputies. This pairing of scientists and engineers at each administrative level proved to be a good technique for assuring that each program office identified and, where possible, resolved its own scientific and technical issues.[16]

Newell chaired a Space Science Steering Committee; the Director and Deputy Director of each of the two new program offices were its other members. To provide technical support to the Steering Committee, he created several scientific subcommittees. An “administrative scientist” from Newell’s staff chaired each of these subcommittees. The membership consisted of academic scientists and scientists from Goddard and JPL; each had a mixture of wise-old-heads and “young Turks.” These subcommittees planned the program in their discipline, reviewed the proposed experiments for a specific scientific mission, and established priorities for their flight on that mission. Through the Steering Committee and its subcommittees, Newell brought together the scientific and engineering talent needed to assure him that a mission was ready for development and that the program office had chosen the best possible experiments. The external scientific community was ambivalent about these changes, which further reduced its influence over NASA’s space science program. [I-18]

Newell decreed that all proposals for scientific experiments would come to NASA Headquarters, and that administrative scientists at Headquarters would manage the process of soliciting, receiving, and evaluating all scientific proposals and selecting the scientists for all space science missions. In April 1960, NASA issued Technical Management Instruction 37-1-1, which specified exactly how NASA would select space scientists to participate in missions and outlined what their role would be during a mission. This has proved to be a durable procedure. Four decades later, NASA continues to use the same basic approach established in this document. [I-20]

James Webb Takes Charge

By the end of 1960, NASA had created a space science organization and established the broad policy and procedures for planning and conducting a space science program, and the program was beginning to produce scientific valuable results.[I-21] Space scientists, however, still had a fundamental problem with the organization at NASA Headquarters; while there were scientists at each level of the organization, those in charge were always ex-NACA engineers, while a scientist served as the deputy at each level. In addition, as new projects began to mature and budgets tightened, a host of serious technical issues emerged.

Overshadowing all of these issues was the future of NASA. Would the new president, John F. Kennedy, support a vigorous space program? Would the new Administrator of NASA continue the policies laid down by Glennan or would he make major changes? What would happen to the fledgling space science program?

On February 14, 1961, new Administrator James E. Webb took charge of NASA.[17] Although he continued the basic policies established by Glennan, Webb took several steps to strengthen the space science program. As part of the Apollo buildup, in 1962 he added a Sustaining University Program with a $40 million annual budget to provide funding for new facilities and graduate student fellowships.(See Volume II, Chapter 3, for a discussion of this program.) In November 1961, he reorganized NASA, abolishing the Office of Space Flight Programs and appointing Homer Newell as Associate Administrator of a new Office of Space Science (OSS). Thereafter, Newell reported directly to the administrator of NASA.[18]

Newell continued, but in reverse, the policy of pairing a scientist and engineer. He selected Edgar M. Cortright, an ex-NACA engineer, to be his deputy. He changed the name of the Sounding Rocket and Satellite Program to Geophysics and Astronomy and appointed a scientist as director. He created a Bioscience Program office and appointed a scientist to head it. Each of these new directors selected engineers to be their deputies. This arrangement established the tradition that the Associate Administrator of Space Science would always be a scientist,[19] and that he would always have an engineer as his deputy. The director of a program office could be either a scientist or engineer, but he and his deputy must constitute a scientist-engineer pair.

Webb placed Newell in charge of NASA's launch vehicles for robotic missions. He also placed JPL and Goddard under Newell's direction. He assigned the Sustaining University Program to Newell. Thus, with the exception of the tracking and data acquisition system, Newell had under his direct control all the programs and all the institutions, capabilities, and facilities needed to conduct the space science program. He still, however, had to fight for his share of the NASA budget. He was also directed to provide data on the lunar surface and the radiation levels in cis-lunar space to the Apollo Program. Otherwise, Newell controlled an independent, self-sufficient space science organization.

The space science organization that Webb and Newell established in 1961 continued approximately unchanged until 1974, when NASA Administrator James C. Fletcher reorganized NASA.[20] Fletcher shifted control of JPL and Goddard from OSS to a new Office of Institutional Affairs to assure even-handed treatment of all NASA centers. In anticipation of the shuttle era with a single transportation system, he transferred control of all launch vehicles from OSS to the Office of Manned Spaceflight.[21] These two changes substantially weakened the control of the Office of Space Science over its destiny. No longer was the Associate Administrator of the Office of Space Science head of an independent, self-sufficient office. If he had a problem at a center he had to work through another associate administrator, rather than directly with the center director, to resolve it. Instead of controlling the performance and schedule of his own fleet of launch vehicles, he now had to compete with the other users of the shuttle.

In the early 1980s, another NASA administrator, James M. Beggs, restored control of JPL and the Goddard Space Flight Center to OSS, but not control of launch vehicles. Otherwise, the basic space science organization established in 1960 and modified in 1961 continues to administer the program.

Learning to Conduct a Sustainable Space Science Program

By the mid-1960s, the OSS organization, its two field centers, and associated space scientists were seasoned veterans, able to plan and conduct a successful space science program. Budgets were increasing, annual launch rates were increasing, and scientists were making discoveries. Space scientists sensed no limitations, other than their own energies and imaginations, to their desire to explore and understand the universe. [I-22]

In June 1967, concerned by the management deficiencies found during the investigation of the Apollo 1 fire and looking for ways to improve the management of human space flight programs, NASA Administrator Webb asked Homer Newell to review the philosophy and techniques that he was using so successfully to manage the space science program. The resulting review summarized the hard lessons learned during the earlier troubled times. [I-24]

In the summer of 1967, shortly after the Webb review, Newell and his staff suffered a major setback. Though they had mastered the technical skills required to conduct a space science program, they had not learned the political skills required to maintain scientific support for a mission, or to accurately judge the support they could expect from Congress.

Planetary exploration had begun, like lunar exploration, in a race between the United States and the USSR to see who would be the first to get some sort of spacecraft near Mars or Venus. The Soviets tried for Venus first, launching on February 12, 1961. Unlike the lunar contest, however, the Soviets did not win the race to Venus; their spacecraft failed before reaching Venus. The U.S. *Mariner 2* flew by Venus on December 14, 1962. In June 1963, the Soviets got to Mars first, but with little scientific return. The United States did not get to Mars until July 15, 1965, when *Mariner 4* took twenty-two pictures as it flew past the planet.[22]

In the mid-1960s, as OSS planned its future Mars programs, two problems confronted NASA senior managers. They needed to find missions that required the big Saturn V launch vehicles developed for Apollo, and they had to decide whether to focus the entire planetary program on the exploration of Mars, or to have a more modest Mars program and explore other planets such as Venus and Jupiter. They turned to the Space Science Board for help.

In the summer of 1965, the Space Science Board conducted a summer study that recommended that NASA focus its space science program on exploring Mars, a recommendation that had first emerged in 1964. [I-23] NASA used this recommendation in an attempt to solve both its problems. It formulated a $2 billion program, Voyager, to search for life on Mars, and it canceled plans for missions to other planets. Voyager consisted of a pair of orbiter-landers to be launched on one Saturn V. Despite the positive recommendation of the Space Science Board, Voyager was controversial. Few scientists supported the mission; most opposed it as too risky and too expensive. In the summer of 1967, because of the conflicting testimony from scientists and because of the general shortage of funds due to the cost of the Vietnam War and the needs of the Great Society, Congress killed the project.[23] Voyager was the first major space science project to be killed by Congress. (See Chapter 3 of this volume for further discussion of this controversy over the future of the planetary program.)

OSS and its space scientists learned some hard lessons in practical politics from the Voyager fiasco and the highly constrained budgets of the late 1960s and early 1970s. They learned to resolve their differences in internal scientific discussions, not in complaints to the media or in testimony before Congress. Massive scientific backing could not guarantee Congressional support for a mission, but massive scientific opposition could certainly kill it. They also learned that there was an ill-defined limit to the size of a space science mission and the annual space science budget that Congress would support.

In the fall of 1967, Webb reorganized the Office of Space Science and renamed it the Office of Space Science and Applications (OSSA). He promoted Homer Newell to be NASA Associate Administrator, the agency's number three job. He replaced Newell with John E. Naugle, a scientist, appointed Newell's deputy, Edgar Cortright to be Deputy Director of the Office of Manned Space Flight, and replaced him with Oran Nicks, an engineer.

To avoid future problems, OSSA formed a Lunar and Planetary Mission Board and an Astronomy Mission Board. OSSA created the Boards to assist in planning future missions and to provide a forum to identify and resolve differences among scientists and between the scientists and OSSA.[24]

Between November 1967 and November 1968, NASA's Office of Space Science, the Lunar and Planetary Mission Board, the Space Science Board, and the scientific community hammered out a mutually acceptable planetary program for the 1970s. Although the program continued to emphasize the exploration of Mars by recommending the Viking orbiters and soft landers and two other Mars orbiters, it also included a Venus-Mercury flyby, two Pioneer missions to Jupiter and Saturn, and a "Grand Tour" of all the outer planets except Pluto. Except for a two-year delay in Viking, loss of one of the other Mars orbiters, and a downsizing of the Grand Tour spacecraft to become Voyager, this program was carried out exactly as planned.[25]

Relations between NASA's Office of Space Science and Office of Manned Space Flight were strained throughout the 1960s. Space scientists resented the priorities and media attention enjoyed by the Apollo program. They complained about the lack of plans or funding in the Apollo program for lunar research. When NASA decided to include lunar research in Apollo, questions arose as to whether OSS or the Office of Manned Spaceflight (OMSF) should be responsible for it. In September 1966, Robert C. Seamans, NASA Deputy Administrator, assigned responsibility for all space science, including that to be performed on crewed spacecraft, to the Office of Space Science, but decreed that the funding be carried in the OMSF budget and then transferred to OSS after Congressional approval.[26] This arrangement further exacerbated the tension between OSS and OMSF. The scientific staff of OSS complained that OMSF would not adequately fund scientific work; OMSF engineers complained that OSS scientists neglected lunar research in favor of other areas of space science. To solve the problem, Newell created a Manned Space Science Division, staffed it with OSS scientists and OMSF engineers, and required that the head of the division report to him on scientific issues and to the head of OMSF on technical and funding issues.

Even so, tensions between the "manned" and "unmanned" elements of NASA and the relevant external communities persisted. As the Apollo program reached its end. [I-25] They were made worse when NASA appeared to ignore the advice of the scientific community as it planned its "post-Apollo" program [I-26, I-27] These tensions have continued until the current time, and appear to be an unavoidable feature of a U.S. civil space program that combines the drama of human space flight activities with a commitment to obtaining top-quality scientific results.

The Emerging Crisis in Space Science

The 1970s were to all appearances a "golden age' for space science. In 1976, two Viking spacecraft landed on the surface of Mars, and in 1977, two Voyager spacecraft began their journeys to Jupiter and Saturn, and perhaps on to Uranus and Neptune. Also in 1976, President Gerald Ford approved "new starts" for two large science missions for launch in the 1980s– a Galileo spacecraft to do in-depth exploration of Jupiter and its moons, and a large space telescope (later named Hubble) that had been a high priority for space scientists for almost three decades. But there were also troubling longer-range trends. The administration of President Jimmy Carter did not give high priority to the space program, and the budget demands of space shuttle development made approval of additional large space science missions difficult. [I-28] Both the Carter administration and, in 1981, the new administration of Ronald Reagan refused to approve a U.S. mission to Halley's Comet.[27] In addition, the Reagan administration directed NASA to cancel one of its ongoing space science missions, and seriously considered terminating the solar system exploration program and transferring the Jet Propulsion Laboratory to some other government agency. (See Volume II, Documents I-8 and I-9, on the cancellation of the International Solar Polar mission that resulted from the 1981 Reagan administration directive, and Chapter 3 of this volume on the threat to terminate the solar system exploration program.)

By 1986, the space science community perceived itself to be in a crisis situation. NASA's Space and Earth Science Advisory Committee concluded that the space science program was "facing grave difficulties," leading to "a growing sense of unease and frustration over the program's diminishing pace." The Committee noted that more and more missions were being identified as candidates for 'New Starts' at a time when prospects for New Starts were becoming uncertain," and that as a result "the competition among prospective missions had escalated to a counterproductive level."[28] [I-29]

New Approaches to Managing Space Science

In 1988, a new head of NASA's Office of Space Science and Applications, Lennard Fisk, took a new approach to dealing with this competition. Rather than having potential missions compete with each other annually to determine which of them NASA would recommend as its next new start, Fisk created a strategic planning process. The first version of this plan, issued in April 1988, noted the "trend toward large, complex, long-duration missions" that had become characteristic of the space science enterprise in the 1980s.[29] The plan set scientific priorities for prospective missions and programs , and thereby determined the order in which various proposed missions would be put forth by NASA for White House and Congressional approval. The plan assumed continuing growth in NASA's budget. It thus proposed that NASA would initiate one major or moderate new mission each year. This was clearly a bullish outlook, given the difficulties of obtaining new start approvals during the preceding decade. [I-30]

The strategic planning approach was initially successful. NASA received new start approvals for three major space science missions between 1989 and 1991—the Advanced X-Ray Astronomical Facility, a Comet Rendezvous-Asteroid Flyby mission, and a mission to do in-depth exploration of Saturn, called Cassini.

A new NASA Administrator, Daniel S. Goldin, came to the space agency on April 1, 1992, with a very different approach to future space science missions, and different expectations for the future of NASA. He directed his associates to plan for a level NASA budget in the future, rather than continued growth. He indicated that Cassini would be the last major space science mission that NASA would propose for some time, and emphasized a "faster, better, cheaper" approach to future mission planning. The rationales behind such an approach rejected the trend toward large, complex, long duration missions that had been stressed in the 1988 and subsequent strategic plans, suggesting that undertaking more missions, each at lower cost and with shorter times between approval and launch, would produce better scientific returns, allow more scientists an opportunity to get involved with NASA missions, and better accommodate an occasional mission failure. [I-31, I-32] Goldin also reorganized the Office of Space Science and Applications, dividing its programs among three new offices—Space Science, Mission to Planet Earth (later renamed Earth Science), and Life and Microgravity Science and Applications.

The continuing tension between space scientists and the human space flight program resulted in a Congressional suggestion that all of NASA's science programs be gathered into a quasi-autonomous "National Institute for Space Science," modeled on the organization of the National Institutes of Health. The thought behind this suggestion was that by making space science somewhat independent of the rest of NASA, its budget could be stabilized rather than be traded off against the budget needs of the human space flight program (in this case, the International Space Station and Space Shuttle operations). A panel of the Space Studies Board (the new name for the Space Science Board, adopted in the late 1980s to signal a broader mandate for the Board) examined this and other suggestions for changing the way that NASA managed space science. While rejecting the idea of a National Institute for Space Science, the Board made other, less far-reaching, suggestions for improving the management of the space science effort. [I-33]

Space Science in the Twenty-First Century

Although he rejected the specific content of earlier space science strategic plans, NASA Administrator Goldin was a strong advocate of the strategic planning process in general. Between 1992 and 1996, he and his associates considered various strategic visions to guide future space science efforts. These efforts were accelerated by President Bill Clinton's call for rethinking NASA's space science program following the August 1996 announcement that a Martian meteorite contained possible evidence of ancient fossilized organisms. (See Chapter 3 for additional discussion of this announcement.) NASA and the National Research Council in October 1996 convened a workshop attended by leading space scientists to consider a reformulation of the rationale for NASA's scientific efforts; the results of that workshop were presented to Vice President Al Gore in December 1996, and formed the basis for White House approval on a new space science initiative organized around the theme "Origins." [I-34] A new space science strategic plan, issued in November 1997, spelled out the initiative in detail and identified the future missions needed to accomplish it. [I-35]

The Origins initiative is addressing a set of "fundamental questions." They include:

- How did the Universe begin and what is its ultimate fate?
- How do galaxies, stars, and planetary systems form and evolve?
- What physical processes take place in extreme environments such as black holes?
- How and where did life begin?
- How is the evolution of life linked to planetary evolution and to cosmic phenomena?
- How and why does the Sun vary and how do the Earth and other planets respond?
- How might humans inhabit other worlds?[30]

In addressing questions such as these, the space science enterprise has in just over a half-century evolved from modest attempts to put a few scientific instruments aboard captured weapons of war to a comprehensive attack on questions that have puzzled humans for millennia. Whatever else happens in space in the 21st Century, space science is poised to thrive.

---

[1] On the IGY see, Constance McL. Green and Milton Lomask, *Vanguard: A History* (Washington, DC: NASA SP-4201, 1971), pp. 6-39; Rip Bulkeley, *The Sputniks Crisis and Early United States Space Policy: A Critique of the Historiography of Space* (Bloomington: Indiana University Press, 1991), pp. 89-122; R. Cargill Hall, "Origins and Early Development of the Vanguard and Explorer Satellite Programs," *Airpower Historian* 9 (October 1964): 102-108; Robert A. Divine, *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite* (New York: Oxford University Press, 1993); Walter A. McDougall, . . . *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985).

[2] David H. DeVorkin, *Race to the Stratosphere* (New York: Springer-Verlag, 1989), pp. 296-304.

[3] B. Occhialini and C. F. Powell, “Nuclear Disintegrations Produced by Slow Charged Particles of Small Mass,” *Nature* 159 (February 8, 1947): 186-90.

[4] P. Freier, E. J. Lofgren, E. P. Ney, F. Oppenheimer, H. L. Bradt, and B. Peters, “Evidence for Heavy Nuclei in the Primary Cosmic Radiation,” *Physical Review* 74 (July 15, 1948): 213-17.

[5] The Panel started life as the V-2 Upper Atmosphere Panel; in 1948 it became the Upper Atmosphere Rocket Research Panel and in 1957, the Rocket and Satellite Research Panel. On this panel see, David H. DeVorkin, “Organizing for Space Research: The V-2 Panel,” *Historical Studies in the Physical and Biological Sciences* 18 (1987): 1-24.

[6] See James A. Van Allen, *Origins of Magnetospheric Physics* (Washington, DC: Smithsonian Institution Press, 1983), and Homer E. Newell, *Beyond the Atmosphere: Early Years of Space Science* (Washington, DC: NASA SP-4211, 1980), for details of the Panel. Newell's book is an outstanding summary of the development of the NASA space science program by its chief architect.

[7] See R. Cargill Hall, *Lunar Impact: the History of Project Ranger* (Washington, DC: NASA SP-4210, 1977).

[8] When Vanguard developed budget problems, even the Central Intelligence Agency (because of its interest in establishing the principle of free satellite overflight) provided some of the project's funding. See Dwayne A. Day, John M. Logsdon, and Brian Latell, *Eye in the Sky: the Story of the CORONA Spy Satellite* (Washington: Smithsonian Institution Press, 1998).

[9] See Van Allen, *Origins of Magnetospheric Physics*; John E. Naugle, *First Among Equals: The Selection of Space Scientists* (Washington, DC: NASA SP-4215, 1991) for more information about the role of TPESP.

[10] "Soviet Embassy Guests Hear of Satellite from an American as Russians Beam," *New York Times*, October 5, 1957, p. A3.

[11] J. A. Van Allen, G. H. Ludwig, E. C. Ray, and C. E. McIlwain, "Observation of High Intensity Radiation by Satellites 1958 Alpha and Gamma," *Jet Propulsion* 28 (September 1958): 588-92.

[12] Newell, *Beyond the Atmosphere*; Robert L. Rosholt, *An Administrative History of NASA*, 1958-1963 (Washington, D.C.:NASA SP-4101, 1966); and McDougall, . . . *The Heavens and the Earth*, provide more details and many references on the forces at work in the 1957-1958 period.

[13] At the time, Newell was Superintendent of the Atmosphere and Astrophysics Division, Naval Research Laboratory. NRL was the organization in charge of the Vanguard Program. Newell and

Silverstein had been discussing the transfer of NRL scientists for sometime before NASA opened its doors.

[14] On the Goddard Space Flight Center and Jet Propulsion Laboratory see, Alfred Rosenthal, *Venture into Space: Early Years of Goddard Space Flight Center* (Washington, DC: NASA SP-4301, 1985); Lane E. Wallace, *Dreams, Hopes, Realities: NASA's Goddard Space Flight Center, The First Forty Years* (Washigton, DC: NASA SP-4312, 1999); Clayton R. Koppes, *JPL and the American Space Program: A History of the Jet Propulsion Laboratory* (New Haven, CT: Yale University Press, 1982).

[15] NASA, *Policy on Space Flight Experiments* (Washington, DC: NASA, December 12, 1958); T. Keith Glennan, *The Birth of NASA: The Diary of T. Keith Glennan*, edited by J.D. Hunley (Washington, DC: NASA SP-4105, 1993), pp. 6-15.

[16] Glennan, *Birth of NASA*, pp. 21-30; Naugle, *First Among Equals*, pp. 58-78.

[17] On Webb see, W. Henry Lambright, *Powering Apollo: James E. Webb of NASA* (Baltimore, MD: Johns Hopkins University Press, 1995).

[18] Rosholt, *Administrative History of NASA*, pp. 217-26.

[19] This tradition was violated during 1982-1987, when an engineer, Burton I. Edelson, served as NASA's Associate Administrator for Space Science and Applications.

[20] On Fletcher see, Roger D. Launius, "A Western Mormon in Washington, D.C.: James C. Fletcher, NASA, and the Final Frontier," *Pacific Historical Review* 64 (May 1995): 217-41.

[21] The formal name of this organization at NASA Headquarters was the Office of Manned Space Flight from the beginning of NASA until August 2, 1982, when it became the Office of Space Flight.

[22] Roger D. Launius, *Frontiers of Space Exploration* (Westport, CT: Greenwood Press, 1998), pp. 35-36.

[23] For a more complete treatment of Voyager, see also Edward C. Ezell and Linda N. Ezell, *On Mars: Exploration of the Red Planet 1958-1978* (Washington, DC: NASA SP-4212, 1984).

[24] NASA Office of Space Science and Applications, *Planetary Program Review* (Washington, DC: NASA, 11 July 1969).

[25] See, Robert S. Kraemer, *Beyond the Moon: A Golden Era of Planetary Exploration, 1971-1978* (Washington, DC: Smithsonian Institution Press, 2000).

[26] On Seamans see, Robert C. Seamans, Jr., *Aiming at Targets: The Autobiography of Robert C. Seamans, Jr.* (Washington, DC: NASA SP-4106, 1996).

[27] John M. Logsdon, "Missing Halley's Comet: the Politics of Big Science," *Isis* 80 (1989): 254-80.

[28] Space and Earth Science Committee, NASA Advisory Council, *The Crisis in Earth and Space Science* (Washington, DC: NASA, November 1986), p. iii.

[29] Office of Space Science and Applications, NASA, *Strategic Plan 1988* (Washington, DC: NASA, 1988), p. 2.

[30] NASA, *The Space Science Enterprise Strategic Plan: Origins, Evolution, and Destiny of the Cosmos and Life* (Washington, DC: NASA, November 1997), p. 4.